An Explorative Econometric Model of Sydney Metropolitan Rail Patronage

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Safe, clean and reliable passenger services
With a little help from our colleagues:

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Overview

- Introduction
- Literature review
- Model
- Patronage trip rate
- Office employment
- Gross state product (GSP) per head
- Rail fare
- Train kilometres operated
Overview

- Other explanatory variables
- Omitted variables
- Correlation between variables
- Estimated model
- Impact of the 2008-09 global recession
- Conclusions
Introduction

- The aim of the research paper:
  - to provide a short to medium term forecasting model of rail patronage.

- The model:
  - an explorative time-series econometric model;
  - demand for Sydney metropolitan rail;
  - annual data 1969 to 2008;
  - regression analysis – year on year change in rail demand;
  - dependent variable – trips per head using factored population;
  - explanatory variables – variation in rail trip rate; and
  - office employment and gross product per head – important determinants of rail patronage.
Literature Review – econometric models of rail demand

- Time series models:
  - intercity models based on commuter rail services in the UK;
  - cross sectional “or gravity type” models; and
  - hybrid time series - cross section approach.

- Elasticities:
  - price;
  - service level; and
  - service quality.

- Mode share models:
  - Sydney travel model

- Revealed and stated preference
Comparison with other studies

- Sydney metropolitan rail patronage:
  - used revenue accounts data;
  - a time series model was fitted to the data; and

- TfL – underground and bus travel in London:
  - a time series model was fitted to the data;
  - data periodicity – four weekly data; and
  - larger number of observations.
Comparison with other studies

- Charles River Associates (CRA):
  - a time series model was fitted to the data; and
  - shorter time series; and
  - absolute level of rail patronage.
Model

- Variation in the year on year change in Sydney metropolitan rail patronage

- Variables:
  - socio-economic;
  - fare;
  - service level; and
  - ‘event’.

- 38 years of accounting data from 1969-70.
Model

- **Dependent variable:**
  - rail patronage divided by factored Sydney metropolitan population;
  - year on year change in rail trip rate.

- specified in ratios to reduce auto correlation. Then **Logged**
$Q = C + \beta_{i} \cdot RF + \beta_{i} \cdot TKMS$

$+ \beta_{i} \cdot MOE + \beta_{i} \cdot RGSPP$

$+ \beta_{i} \cdot MI + \beta_{i} \cdot OLY + \beta_{i} \cdot AFC$
Model

\[ Q = \ln \left[ \frac{Q_t / (\text{Pop}_t)^{0.52}}{Q_{t-1} / (\text{Pop}_{t-1})^{0.52}} \right] \]

\[ Q_t = \text{number of rail trips (millions)} \]

\[ \text{Pop}_t = \text{population of Metropolitan Sydney in millions} \]

\[ RF = RF_t - RF_{t-1} \]

\[ TKMS = \ln \left[ \frac{TKMS_t}{TKMS_{t-1}} \right] \]
Model

\[ MOE_t = \ln \left( \frac{MOE_t}{MOE_{t-1}} \right) \]

\[ RGSP_{t} = \ln \left( \frac{RGSP_t}{RGSP_{t-1}} \right) \]

\[ MI_t = \text{major incident on CityRail taking a value of 1 if an incident occurred else zero.} \]

\[ OLY_t = \text{Sydney Olympics taking a value of 1 if financial year = 2000-01 else zero.} \]
Model

\[ AFC_t = \text{Automatic Fare Collection taking a value of 1 if financial year is 1989-90 or later.} \]

\[ C = \text{constant indicating the average year on year ratio change in patronage level.} \]

\[ \beta_i = \text{parameters to be estimated with } t \text{ denoting year.} \]
Patronage trip rate

Trend in CityRail Patronage 1969-2008
Patronage trip rate

Trend in Sydney Population
Patronage trip rate

Trend in CityRail Trip Rate
Office employment

Trend in Office Employment
Gross state product per head

Ratio Change in Real Gross State Product per Head
Rail fare

Trend in Average Revenue

Average Revenue per Trip

- Nominal Av. Revenue
- Real Av. Revenue
Train kilometres operated

Trend in Train Kilometres
Other Explanatory variables

- Sydney Olympics
- Major Incidents (4)
- Automatic Fare Collection
Omitted variables

- Petrol Price – Currie
- Car Parking $$$ in CBD
- Bus Fares
- Rail Service Level …..
- Tourism
- Retail Activity
- Accessibility to the Rail network
Correlation between variables

Correlation Matrix

<table>
<thead>
<tr>
<th></th>
<th>Q</th>
<th>RF</th>
<th>TKMS</th>
<th>MOE</th>
<th>RGSPPH</th>
<th>MI</th>
<th>OLY</th>
<th>AFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger Trip Rate</td>
<td>1</td>
<td>-0.22</td>
<td>0.24</td>
<td>0.25</td>
<td>0.38</td>
<td>0.04</td>
<td>0.24</td>
<td>0.13</td>
</tr>
<tr>
<td>Real Fare Difference</td>
<td>-0.22</td>
<td>1</td>
<td>0.06</td>
<td>0.18</td>
<td>-0.16</td>
<td>-0.34</td>
<td>0.09</td>
<td>-0.01</td>
</tr>
<tr>
<td>Train Kilometres</td>
<td>0.24</td>
<td>0.06</td>
<td>1</td>
<td>0.11</td>
<td>0.02</td>
<td>0.02</td>
<td>0.17</td>
<td>-0.27</td>
</tr>
<tr>
<td>Metropolitan Office Employment</td>
<td>0.25</td>
<td>0.18</td>
<td>0.11</td>
<td>1</td>
<td>0.39</td>
<td>0.11</td>
<td>0.00</td>
<td>-0.15</td>
</tr>
<tr>
<td>Real GSP per Head</td>
<td>0.38</td>
<td>-0.16</td>
<td>0.02</td>
<td>0.39</td>
<td>1</td>
<td>0.15</td>
<td>-0.04</td>
<td>0.12</td>
</tr>
<tr>
<td>Major Incidents</td>
<td>0.04</td>
<td>-0.34</td>
<td>0.02</td>
<td>0.11</td>
<td>0.15</td>
<td>1</td>
<td>-0.06</td>
<td>0.17</td>
</tr>
<tr>
<td>Olympics</td>
<td>0.24</td>
<td>0.09</td>
<td>0.17</td>
<td>0.00</td>
<td>-0.04</td>
<td>-0.06</td>
<td>1</td>
<td>0.16</td>
</tr>
<tr>
<td>Automatic Fare Collection</td>
<td>0.13</td>
<td>-0.01</td>
<td>-0.27</td>
<td>-0.15</td>
<td>0.12</td>
<td>0.17</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Q, TKMS, MOE, RGSPPH specified as ratios (t/t-1) with logarithms taken. RF specified as difference (t-(t-1))
### Estimated model

| Var | Variable Description                                      | \( \beta \) | Standard Error | \(|t|\) | \( \approx \text{Prob } \beta > 0 \) (1) |
|-----|-----------------------------------------------------------|-------------|----------------|--------|---------------------------------------|
| AFC | Automatic Fare Collection (1 if 1989-90 or greater, else 0) | 0.021       | 0.018          | 1.170  | 74%                                   |
| OLY | Olympics (1 if 2000-01, else 0)                          | 0.064       | 0.052          | 1.226  | 76%                                   |
| MI  | Major Incident (1)                                       | -0.028      | 0.029          | 0.971  | 64%                                   |
| RGSPPH | Real Gross State Product per Head                       | 0.740       | 0.528          | 1.401  | 83%                                   |
| MOE | Metropolitan Office Employment                           | 0.613       | 0.452          | 1.357  | 81%                                   |
| TKMS | Train Kilometres Operated                                | 0.246       | 0.156          | 1.574  | 87%                                   |
| RF  | Real Fare (real fare per trip)                           | -0.113      | 0.061          | 1.860  | 93%                                   |
| C   | Constant                                                  | -0.042      | 0.017          | 2.559  | 98%                                   |

| R Squared | 0.35 |
| Number of Observations | 38  |
| Degrees of Freedom     | 30   |

(1) Prob > 0 gives the percentage probability for a 2 tailed test that the parameter estimate is greater than zero (with 40 observations)

(2) MI took a value of 1 if year of Granville, Brooklyn, Glenbrook or Waterfall else zero
Patronage and fare elasticity
Impact of the 2008-09 Global Recession

Estimated CBD White Collar Employment vs Total CityRail Rolling 12 Month Passenger Journeys

- 12 Months Passenger Journeys (Millions)
- Estimated CBD White Collar Employment (Thousands)

Legend:
- 12 Month Journeys
- Estimated CBD White Collar Employment
Conclusions

- Annual rail patronage for 38 years modelled;
- Data: socio-economic, fare, train operating kilometres and other factors;
- Two variables describing economic activity Metropolitan office employment (MOE) and Real Gross State Product per Head (RGSPHH).
- Strong positive relationship with rail patronage. 10% increase in MOE increases patronage 6.1% 10% in RGSP raises rail patronage 7.4%.
Conclusions

- Fare and train kms reasonable
- Others reasonable but with estimation error
- The model is exploratory some variables not yet included
- include when annual data replaced by four weekly or quarterly data.
Questions